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The only case which remains unsettled is that of $\beta(ii)$, and it may now be seen from the first member of (1) that $\beta'(ii) \angle o$. For convenience of reference we may now summarize our results:[5]

$$\begin{array}{llll}
\alpha(oo) \angle o, & \alpha(oi) \angle o, & \alpha(io) \angle o, & \alpha(ii) \angle o, \\
\beta(oo) \angle o, & \beta(oi) \angle o, & \beta(io) \angle o, & \beta'(ii) \angle o, \\
\gamma'(oo) \angle o, & \gamma'(oi) \angle o, & \gamma(io) \angle o, & \gamma'(ii) \angle o, \\
\epsilon'(oo) \angle o, & \epsilon'(oi) \angle o, & \epsilon'(io) \angle o, & \epsilon(ii) \angle o.
\end{array}$$

Let me in concluding add a word of reply in advance to those critics whose habit of thought will be sure to lead them to a misunderstanding of the possibilities that have just been pointed out. If two systems of inference contradict one another, they will say, then, if one be true, the other must be false. To this one must agree, but one might add that it may very well be meaningless to assert that either one is unconditionally true. The characteristic axiom of Riemannian space contradicts that of Euclidean space, but the "space of our experience" illustrates the one geometry quite as much as it illustrates the other. Two contradictory hypotheses can not both be true, because this is part of the meaning of their being contradictory, but each may well enough be applicable to one and the selfsame world. Surely pragmatic philosophy is directly served, whenever we can show that the world is plastic enough to illustrate two hypotheses indifferently, even when these two stand in direct contradiction to one another.

HENRY BRADFORD SMITH.

UNIVERSITY OF PENNSYLVANIA.

SOCIETIES

AMERICAN PHILOSOPHICAL ASSOCIATION: PRELIMINARY MEETING OF LEADERS OF THE DISCUSSION ON MECHANISM VERSUS VITALISM

MEMBERS of the Philosophical Association are aware that at the Princeton meeting last December a new scheme was adopted for organizing pre-arranged discussions. The incoming Executive Committee was instructed to put the scheme into operation for the meeting next December, and invited me to act as organizer of the leaders of the discussion. In consultation with our president (Professor Mary Whiton Calkins) and, through her, with the other members of the Committee, *Mechanism vs. Vitalism* was fixed on as the most promising topic for debate, and the following were chosen to form the group of leaders, *viz.*, Professor L. J. Henderson (Harvard University), representing Physics and Chemistry; Professor H. S. Jennings (Johns Hopkins University), representing Biology; Professor H. Warren (Princeton University), representing Psychology; and Professor W. T. Marvin (Rutgers College), representing, together with myself, Philosophy. It was thought desirable to invite the cooperation of three scientists, in order to have the different angles of approach to our problem represented as competently as possible. The thanks of the association are due to Professors Henderson, Jennings, and Warren, for their willingness to desert for this occasion the meetings of their own associations, and for their most helpful and loyal cooperation.

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[5] In the particular logic, whose foundations have just been set down, it will be found that the ordinary syllogism, $xy \angle z$, contains twenty-one valid moods; that $xy' \angle z'$ and $x'y \angle z'$ contain twenty-three and nineteen respectively, and that $xy \angle z'$ contains one hundred and fourteen. It will be found too that no other valid syllogistic variations exist except those just enumerated. The forms of inference built up out of α, β, γ and ϵ, which correspond to those of the common logic, have been fully treated in the writer's *Primer of Logic* (B. D. Smith and Bros., Pulaski, Va., 1917). A reference to that work will suggest the manner of working out the alternative systems proposed in this article.

The preliminary meeting of leaders, called for by the new scheme, was held at Harvard University on June the twenty-first and twenty-second, between five and six hours on each of these two days being devoted to planning the general scope of the discussion and outlining the arguments which each leader will attempt to present at the discussion itself. A selected list of books and articles bearing on our topic will be published by us in the JOURNAL early in September. We have also agreed to submit our papers, in their final form, for publication during the fall, so that they may be in the hands of members of the association prior to the meeting. The drift of the discussion at our preliminary meeting made it appear desirable to frame our individual arguments on a common *basis of reference.* This basis of reference, which is submitted herewith to members of the association, together with brief abstracts of the proposed arguments of the leaders, attempts to exhibit the place of "mechanistic" concepts in the existing system of the Natural Sciences, and thus to define the general theoretical context within which the problem of the nature and status of "life," or rather of living beings, arises, and to which all attempts at a solution must be relevant. It should, however, be clearly understood that *this statement is strictly nothing but a basis of reference upon which our arguments can converge.* It is not put forward dogmatically, or even with complete unanimity, as a common doctrinal platform. On the contrary, although this statement was exhaustively discussed and its language shaped by all of us, we agreed that no one of us should be held committed to every detail of assertion that it contains, or every implication that ingenious critics may read into its phrases. Indeed, there was nothing, perhaps, more clearly brought home to us than the difficulty of condensing into a brief statement this general background of our argument, so as to suggest nothing but the interpretations supplied by the context of our actual discussions, and in that context found acceptable with individual qualifications and reservations here and there. Hence each leader was left free to define, so far as he may think fit to do so, in his individual contribution, how far he accepts, or differs from, this basis of reference, and how his arguments bear upon it.

In general, I think, we all felt that this first part of the new scheme was an unqualified success. At least we were unanimous on having thoroughly enjoyed our discussion.

R. F. ALFRED HOERNLÉ.

BASIS OF REFERENCE

What follows attempts to be an objective statement of the present condition of science, bearing on the problem of Mechanism and Vitalism:

1. A geometrical description of the universe has been found applicable, without measurable imperfection, to all parts of the universe in so far as they occupy space. All material objects, all living bodies, are geometrical.

2. A kinematical description of the universe also has been found applicable, without measurable imperfection, to all parts of the universe which occupy space. This description involves time and motion as well as space. All material objects, all living bodies, are kinematic.

3. A mechanical description, involving the further concept of mass, also has been found applicable, without measurable imperfection, at least to all large masses. All large material objects, all large living bodies, are mechanical.

4. A physico-chemical description, involving such concepts as chemical composition, differentiation into phases, concentration, and every kind of potential, also has been found applicable, without measurable imperfection, in the preliminary survey of all molecular systems. All living bodies are molecular systems, or, in other words, are physico-chemical.

5. A description in geometrical, kinematical, mechanical, and physico-chemical terms may be called a *mechanistic* description.

6. The evidence in favor of the complete validity of the mechanistic description consists in its continuous development without any check, and in the fact that all quantitative measurements are consistent with such a description.

7. The discrimination of living bodies from other physico-chem-

ical systems rests upon certain common characteristics of the former class of systems. These characteristics are probably best described by the words organization and regulation.[1] It is true, however, that regulation, and perhaps also organization, can occur elsewhere. Living organisms may also be characterized by assigning the words function and teleology to their behavior or their constitution. They are, nevertheless, mechanistic through and through because they are physico-chemical systems, manifesting mechanical phenomena, kinematical phenomena, and geometrical characteristics.

8. The ascending scale from geometry to physical chemistry and on through the organic to what Spencer calls the super-organic is not to be regarded as a classification which has been worked out with complete success. Nevertheless, the several sciences involved include all the known kinds of natural phenomena, at least below the level of the organic, and perhaps below the level of mind. Moreover, the whole experience of science shows that these several departments of science are strictly additive and cumulative. The kinematical is the geometrical plus something else. The mechanical is the kinematical plus something else, and so on. There is much room for difference of opinion whether these successive increments are homogeneous or heterogeneous. But this is probably a matter of definition or of scale. What is important is the vast induction that they involve only addition.

ABSTRACT OF PAPER BY PROFESSOR HENDERSON

A decision between mechanism and vitalism, regarded as mutually exclusive interpretations of living things, is not at present possible. On the one hand it may be truly said that mechanism has never been proved wrong and gains ground steadily. But the reply to this is that the very types of phenomena, *e. g.*, those possessing singularities of various kinds, catalytic actions, *etc.*, which to the physical scientist appear to be the only conceivable sphere for true *vitalism,* are not yet well investigated. Scientifically, therefore, the evidence for mechanism amounts to a strong probability, weakened by the fact that some of the important cases have not been settled.

Logically, I incline to the opinion that all statements of strictly anti-mechanistic vitalism are meaningless. Especially am I convinced that such views as those of Boussinesq, Charles Peirce, J. S. Haldane and others, which seek to add something heterogeneous to mechanism, or to abandon it by rising to a higher level, in effect destroy our only means of thinking about physical phenomena.

Upon the other hand, I agree with Haldane that it is hardly possible to overemphasize the importance of organization as a qualification of all bio-physics and bio-chemistry.

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[1] The addition of growth, reproduction, nutrition was suggested by one member.

ABSTRACT OF PAPER BY PROFESSOR H. S. JENNINGS

(A discussion of the practise and progress of biological science in relation to the above formulation of the status of general science as bearing on the problems of mechanism and vitalism.)

The relatively incomplete formulations given by biological science at its present stage of development would yield, taken by themselves, only fragments of the various kinds of scientific description set forth as existent, in the general statement. Therefore the discussion centers about those underlying relations in the perceptual phenomena which make scientific formulation possible. These relations may be characterized as the prevalence of *experimental determinism;* they lie in the fact that all perceptual phenomena are so interconnected that when one is experimentally altered, certain others are likewise altered. Temporally these relations manifest themselves in the fact that all later perceptual diversities in systems are experimentally determined by earlier perceptual diversities in the systems. The correspondences of diversities are found to fall into a system which constitutes the various types of scientific "descriptions" set forth in the general statement.

The progress of examination indicates that such experimental determinism holds rigorously throughout the living. No case is known of perceptual diversity that is not experimentally determined by a preceding perceptual diversity. In opposition to theories of vitalism that maintain experimental indeterminism (Driesch), this applies notably to regulatory processes in development; to adaptive or purposive actions in general; and to the diversities in the phenomena commonly called "states of consciousness." Experimentally, the latter are bound up with objectively perceptual diversities, preceding and succeeding, as are other phenomena.

These relationships make possible in the science of the living the same general type of formulation as in the science of the non-living. They leave no place for non-perceptual determiners of perceptual events, save as assumed accompaniments to the perceptual determiners.

But the conditions in biology do not imply the deducibility of all biological phenomena from any general proposition or set of such; do not imply that biological phenomena are theoretically predictable from a complete knowledge of any part, or the whole, of the non-living. They do not imply even that the motions and configurations of the living are essentially predictable from a knowledge of the motions and configurations and their laws of change in the non-living. So far as biological experimentation goes it is possible that the laws of motion drawn from a study of the non-living are not complete, but require essential additions from the study of the living. In particular it is not impossible that special laws become manifest when there is "consciousness" in its various types. This involves no breach of objective experimental determinism, the diversities of consciousness being conditioned by diversities in objective perceptual conditions (configurations not found in the non-living).

It is consistent with the complete experimental formulation of biological science that types of phenomena should occur in the living that do not occur in the non-living (the production of asymmetrical crystals?; the occurrence of objects combining typical forms with changing chemical constitution?; non-obedience to the second law of thermodynamics?; the occurrence of consciousness?, *etc.*) All these are questions of fact, not altering the general type of formulation of the science, in accordance with experimental determinism.

ABSTRACT OF PAPER BY PROFESSOR H. C. WARREN

1. Professor Henderson's formulation is thoroughly acceptable to me, with the exception of Article VII., which seems in certain respects inadequate or at least not sufficiently explicit. I would restate this article as follows:

> VII. The discrimination of living bodies from other physico-chemical systems rests upon certain common characteristics of the former class of systems. These characteristics are probably best described by the terms *organization, nutrition, growth, regulation, repair,* and *reproduction.* It is true that each of these characteristics may occur elsewhere. Their combination, however, which results in the maintenance of individuals for a long period, and of the class of living systems for an indefinitely long epoch, may at present be regarded as the specific characteristic of living bodies. Living bodies may also be characterized by assigning the adjectives *functional, responsive, retentive,* and *anticipatory* to their behavior or to their constitution. They are nevertheless mechanistic through and through, because they are physico-chemical systems, manifesting mechanical phenomena, kinetical phenomena, and geometrical characteristics.

2. It should be noted that the antithesis between mechanism and vitalism is really not complete: (*a*) One might accept the notion of mechanism as defined in these articles and at the same time describe the phenomena of living bodies in terms of a specific *vital force*—that is, a specific mode of activity different from physico-chemical activity. According to this view a living body is a *vital mechanism,* belonging to a higher additive level than physico-chemical mechanism.

(*b*) On the other hand, if the behavior of living bodies is conceived to be in any respect indeterminate (or determined by an entelechy, psyche, or other agent distinct from the activity itself), this class of systems falls outside the sphere of mechanism. But the same is true of non-living bodies also. According to the ancients not only vital phenomena, but many physical and chemical phenomena also, are non-mechanistic.

3. One line of argument often used in support of vital indeterminism or entelechism is based upon the analogy of human consciousness and volition, which are assumed to be autonomous and non-mechanistic. Accordingly my paper will examine the nature of those human activities which are generally designated as *conscious* and *voluntary,* with special reference to their supposed indeterminateness.

The standpoint of the paper is that according to the weight of present evidence (1) *all human activity, including deliberation and selective volition, is completely mechanistic;* and (2) *this mechanism is physico-chemical in type.* While certain phases of human activity are found to be far more intricate than any other known physico-chemical mechanism, this is due to the tremendous complexity of the phenomena, not to their novelty. Psychology, thus interpreted, affords no support to vitalism or to indeterminism.

4. Living bodies (organisms), whether regarded as conscious or not, (*a*) are able to act upon data from *past* and *future,* and upon data from *afar,* as well as upon present, contiguous data. Moreover, (*b*) their responses to stimuli tend in general to be *suitable,* or *fit.* Taking into account these two characteristics, the behavior and structure of organisms may be called *teleological.*

The paper will maintain that according to present evidence (3) *the teleological character of organisms is completely mechanistic and physico-chemical.* There is at present no adequate ground for assuming the activity of a specific vital force or entelechy, or for assuming any indeterminateness in the growth activities or behavior activities of organisms.

ABSTRACT OF PAPER BY PROFESSOR W. T. MARVIN

The issue between physico-chemical mechanism and vitalism is not one of facts (phenomena, or observed data), but of theories (or explanations). It is essentially philosophical and is part of a more general philosophical issue. On the one hand is the philosophy of modern science going back at least to Galileo, on the other hand is romanticism.

The former is manifested in the following scientific attitudes, or prejudices.

1. Though several (or even many) independent postulates form the basis of science and though many indefinable notions form the

basis of definition of the remaining concepts of science, still these all should be reduced to a minimum. These postulates and notions are mathematical, physical, and chemical, and perhaps the last may be reduced to the physical. In these postulates we have the sufficient conditions for the remainder of science and in this sense science is logically continuous.

2. Second is the prejudice of determinism. All facts have their sufficient conditions, that is to say, can be explained. Diverse events, properties, or effects always presuppose diverse conditions, structures, or antecedents.

3. Though the facts of life and of mind constitute an extremely complex and difficult array of data to be explained adequately or completely by the logically prior sciences, still our persisting inability so to explain them is due not to the facts themselves, but to our ignorance and imperfect experimental technic. No fact has thus far been shown to be either inconsistent with physico-chemical science or inexplicable by this science. Rather continued successes have met experimental research (especially since the early nineteenth century) in explaining many vital and mental facts mechanistically.

4. The admitted novel facts of life and of mind or combinations of facts are to be explained as the consequences of higher levels of organization; for organization both in the field of the lifeless and in the field of the living exhibits properties not present in the elements or members of the organized system. Hence it is believed that organization without the assumption of further postulates will explain both life and mind.

5. However, it may be true that there are genuinely discontinuous facts exhibited by these organizations, such as the sensory data of minds, but these discontinuous, or inexplicable facts are always in one to one correspondence with configurations of the organized system and these configurations can be explained mechanistically. That is, we have to admit that the majority of scientists during the past three centuries have found in mental states facts logically discontinuous with physics. Hence in psychology have appeared such postulates as parallelism, the double aspect theory, and interactionism. Still there have also been scientists hopeful enough to believe that science may in time analyze these discontinuous facts and find no break in the logical continuity of science. If there are such discontinuous facts there seems to be no reason to assume that they are to be found only in the fields of consciousness, although scientific tradition seems to place them all there.

6. The remarkable traits of life and of mind, such as chemical auto-synthesis, adaptation, regulation, and in general the functional

and teleological traits are the consequences of natural selection, or equilibrium, and presuppose the same postulates that explain equilibria in the field of the lifeless.

In contrast with mechanism, vitalism exhibits the following traits.

1. It is deeply impressed with the variety, diversity, and uniqueness of the facts of life and of mind. It finds in science a gross oversimplification of these facts or even a blindness to many of them.

2. It is more primitive than science. It is a persisting animism coming from our remote past, "a call of the wild."

3. It has a religious motive. The world would seem more in tune with the heart of man, life would seem more mysterious and venturesome, if both were inexplicable, or if both contained creative agents, teleological agents, and genuine spontaneity.

In my paper I shall try to show that in our present ignorance the best method of meeting the issue raised is the pragmatic.

1. Lived up to consistently, romanticism is a return to savagedom. Civilization presupposes skill and explanation. It presupposes that man can understand and control himself and his environment.

2. Science depends upon experimental research and this in turn presupposes that diverse events, properties, or effects always presuppose diverse discoverable conditions. Vitalism seems to deny this; for it seems to assert that agents or factors are present that by hypothesis can not be analyzed, that have no structure, and that possess powers which are genuinely creative (powers that are inconsistent with the principles of thermodynamics).

3. Romanticism and in particular vitalism seem to be symptoms of discouragement and fatigue. Vitalism is ready to quit, to declare the enterprise of explaining life and mind by theories consistent with physico-chemism impossible, and is not hopeful enough to ascribe our present inability to ignorance.

4. Vitalism is, however, pragmatically valuable in its extreme empiricism. It warns us against overlooking facts, against rash and premature simplification of facts, and against blindness to the novelty, uniqueness, complexity, and teleology of life and mind.

In conclusion I would add that I agree with Professor Henderson's statement of physico-chemical mechanism and prefer Professor Warren's restatement of paragraph 7, though the more general wording of Professor Henderson may be advisable.

ABSTRACT OF PAPER BY PROFESSOR R. F. A. HOERNLÉ

In the course of the argument which I hope to contribute to the discussion, it is, at present, my intention to deal with the following points:

1. Our basis of reference seems to me to afford a good opening for discussing how far, and in what sense, a *unified* theory of the universe is possible. As against the two extreme views (*a*) that such unification must be achieved exclusively in mechanistic terms, or (*b*) that, failing this, we must admit absolute discontinuities in the scheme of things, I shall try to argue for unification by correlation of differences—a concept of the universe as, so to speak, a stratified system, implying an order, in which differences may be correlated with, but can not be dissolved into, each other.

2. On this basis, therefore, it will be possible to argue (*a*) for the "autonomy of life," *i. e.*, of the characteristic concepts which biology needs in order to give an adequate theory of the living as distinct from the non-living; (*b*) for mechanical and biological concepts as complementary and "cumulative," not as mutually exclusive. I accept the view that the phenomena of life rest on physico-chemical mechanisms, but I insist that they must also be dealt with *in their own terms,* and that we should not regard it as the ideal of science some day to be able to discard, *e. g.,* the terms appropriate to the theory of animal or human behavior in favor of an account expressed exclusively in terms of physico-chemical formulæ. This recognition of the "autonomy of life," which seems to me the empirical truth in Vitalism, does not, I think, necessitate the concepts of a specific vital force, or vital energy, or Drieschian entelechy.

3. It does, however, raise the problem of the sense in which teleological concepts are applicable. To eliminate from biology the concept of purpose, so as to retain solely the concept of cause and effect, involves, I shall try to argue, an undeniable loss. My argument will require (*a*) a brief analysis of the concepts of determinism and causality, especially as employed in experimental research; (*b*) the attempt to establish a sense of "purpose" which does not imply conscious design, still less a designer, after the manner of the old physico-theological proof. A comparison of machines in the strict sense, *i. e.,* man-made artefacts, and living organisms will here be found relevant, and throw light on the general relation of mechanical to teleological concepts.

REVIEWS AND ABSTRACTS OF LITERATURE

Applied Psychology. H. L. HOLLINGWORTH and A. T. POFFENBERGER. New York and London: D. Appleton and Company. 1917. Pp. xiii + 337.

Psychology has indeed become a subject of great and widespread interest to-day to the popular mind. An increasing number of peo-